PROCEEDINGS OF THE BRITISH
KINEMATOGRAPH SOCIETY

No. 14

"The Cooke Photographic Lenses"

With Special Reference to Colour Corrections

By
Mr. E. ORAM

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Meeting of the British Kinematograph Society

Held at

Gaumont-British Theatre, Film House, 142, Wardour Street, W.1

On

Monday, January 2nd, 1933

CHAIRMAN : Mr. S. Rowson.

LECTURER : Mr. E. Oram, on " THE COOKE PHOTOGRAPHIC LENSES," with special reference to colour corrections.

CHAIRMAN : A statement was made in the minutes of the last Meeting which I have to comment on, and that is the statement that there would be elections of Officers and Executive at this present Meeting. It was, however, found necessary to ask you to agree to postpone that to the next Meeting, on February 6th, because January 2nd is too soon after the 31st December to get the accounts closed.

The next Meeting, therefore, will be the usual Annual Meeting, and the election of Officers and Executive will take place then. The necessary papers in connection with this election will be sent you within the next week or so.

Before I call on Mr. Oram I have one or two brief announcements to make. The first is in connection with the visits which are set forth in the brochure ; arrangements for the next visit have now to be made. The last one arranged to the B.B.C. was a considerable success, but the number of members we were permitted to introduce was limited. They did not allow us to take more than 75 of our members, and not more than 15 at a time, the result being that many members who would have liked to go applied too late and were left in the cold. Those who did go got an insight into the marvellous ramifications of a big business, and were agreeably surprised at the various technical details.

The next visit is to the Kodak Works, and here I have to make a statement to the following effect : we have said that we would like this visit to take place on a Saturday afternoon ; they now inform us that whilst they would be willing that this should be done, there would be very little we should see, as the film works shut down at noon. They are willing, however, to act as hosts and guides if we could fix a week-day visit, and they are willing to take over from eleven o'clock in the morning, give us lunch, and continue the visit round the works in the afternoon, and give everyone who cares to come a really good insight into the methods of making and processing cinematograph film. I have to put this before you because some may find it difficult to get away on a week-day afternoon, but if a sufficient number can join we shall be glad to know to make arrangements. I hope, therefore, that all members, to whom the enquiry will

be sent in the course of a few days, will let us know at once whether they are able to go on a Tuesday afternoon. The actual date has not been fixed, but the Kodak Company suggest Tuesday, January 31st, at eleven o'clock in the morning. The enquiry will, therefore, go out to this effect.

Another little matter : the Executive understand that it is the desire of many members that the Society provide a badge suitable for use on certain occasions such as the meetings of the Society, or when the Society is visiting. We now have such a badge, which has been specially designed, and I think looks very neat. The price is 3s. 6d., which, I understand, is very much less than we originally agreed they should cost. It is a distinction to be a member of the B.K.S., and we are trying to make it a distinction of increasing value. I hope all members will wear one of these badges, and wear it, at least, at all meetings of the Society.

The next meeting will take place on the first Monday in February, the 6th, and the paper will be by Mr. T. Thorne Baker, on " AIR CLEANING AND CONDITIONING," which will be of special interest to those connected with studios and laboratories. I will now call upon Mr. Oram to read his paper.

COOKE PHOTOGRAPHIC LENSES WITH SPECIAL REFERENCE TO COLOUR CORRECTION

As it is necessary to review past developments before dealing with the questions of lens designs, I would like to point out that these were reviewed by Mr. Warmisham, of Taylor, Taylor & Hobson, Ltd., in a paper given some time ago to the Society of Motion Picture Engineers.

I do not propose to make any apology for more or less repeating some of his summary of these developments as many of our members were not members of that society, and the information may, therefore, be of interest to them.

In order to appreciate the present-day status of photographic lens design and construction we have to survey the rapid developments which have taken place in the last 12 or 14 years. Included in these developments we find not only an enormous scaling up in the speed required from photographic objectives, but also totally new demands on both the function and performance of objectives, so much so that in many constructions in use to-day we are literally on the margin of physical possibilities with existing materials.

In 1919 and 1920 there were far more lenses being made for still photography than for kinematography. Lenses of apertures F/6.3 were most popular with F/4.5 coming close behind. F/3.5 lenses were known and largely used for kinematography.

Quite a number of the old camera-men still think that the optical industry has produced nothing better than these 2 in. and 3 in. F/3.5's.

It is very necessary to bear in mind, however, that studio conditions in those days were very different from those we have now. The two main points of difference bearing on our present subject are that lighting was almost wholly by arcs or mercury vapour lamps, and the negative film was the ordinary stock. Since these two conditions were not seriously different from those in the portrait studio, it was possible to satisfy the kinematographer's requirements by a small scale version of the F/3.5 Anastigmats which had been developed some years previously for portrait photography. It was about this time that the Cooke F/2 lens was designed at Leicester by the mathematician Lee. This was the first anastigmat of aperture F/2 and the fate of the efforts to put it on the market are interesting.

Kinematographers were practically unanimous in having no use for such a wide aperture, because it could not provide the depth of field characteristic of the F/3.5 lenses. As regards still photography—well, there was not a camera on the market to which it could be fitted. The general opinion was that it was unusable.

However, an astronomer secured some remarkable photographs of meteorites with one of these 8½ in. F/2 anastigmats, and the Royal Air Force also found use for the lens in night photography from airplanes. For the photography from planes, the illuminant consisted of flares dropped just before the exposure was made.

For two or three years the demand for these lenses was small, and the only good thing that came out of the F/2 was the development of an F/2.5 anastigmat.

It was because of the difficulty of fitting F/2 lenses to reflex cameras that the camera makers asked for a fast lens of less bulk. This resulted in the design and construction of the F/2.5 lens, which became popular on still cameras. Like the F/3.5 portrait lenses, this was, in its smaller sizes, later adopted for kinematograph work.

It was not until six or seven years ago that the studios (chiefly the American studios) began to call for F/2 lenses in any quantity, and the kinematographers became accustomed to working with these larger apertures. Before the talkie pictures came, the F/2 series became thoroughly established with both the amateur and studio photographer.

With the coming of talkies it was found necessary to substitute the arc lamps and mercury vapour lamps with incandescent lamps in order to meet the need for silence in the studios, and to get the best results from panchromatic stock, which became popular about this time. This change in light with its lower actinic value called for more lights or greater lens speeds. As the artistes could not be subjected to more light, with its resultant heat, and as more light meant increased current consumption, the F/2 lenses became very strongly in demand.

This sudden change over to panchromatic and incandescent lighting was not foreseen by us, and there is no doubt it took other optical houses by surprise.

The best lens we knew how to make for previously existing conditions was not right for the new conditions. To explain the difference, it is necessary to review a little elementary optical theory.

SLIDE No. 1

The effect of the lack of chromatic corrections is clearly shown on this diagram.

As you are no doubt aware, if light is passed through a small aperture, and then through a prism on to a screen, a patch of coloured light is seen, the colours covering the range of the spectrum. The prism splits up the white light by refracting or bending the different colours to different extents—the red least and violet most. Similarly, a lens.

With a simple lens as shown, the blue is focussed nearer the lens than the red. This is axial chromatic aberration. Images near the edge of the field or film will have coloured fringes, and this is oblique chromatic aberration, showing a difference in magnification of the image for different colours.

When any lens has been brought to the best possible state of chromatic correction, there is left what the designers know as the secondary spectrum. This does not imply bad design or faulty workmanship, but is the inevitable result of the properties of glass. There is one known way of eliminating this secondary spectrum, and this method is employed in the manufacture of Apochromatic microscope objectives. For these, crystalline mineral fluorite is employed in the place of crown glass. Unfortunately, this fluorite can only be used for small diameters, usually up to about .2 in., owing to the nature of the material and the difficulty of manufacture.

The glass makers have tried to make a similar thing in glass, so that photographic lenses can be corrected for the secondary spectrum, and have succeeded up to a point. With this special glass it is possible to reduce considerably the secondary spectrum, but the construction (slide 2) is so complicated that the lens is too expensive for ordinary purposes or for film studios.

SLIDE No. 2

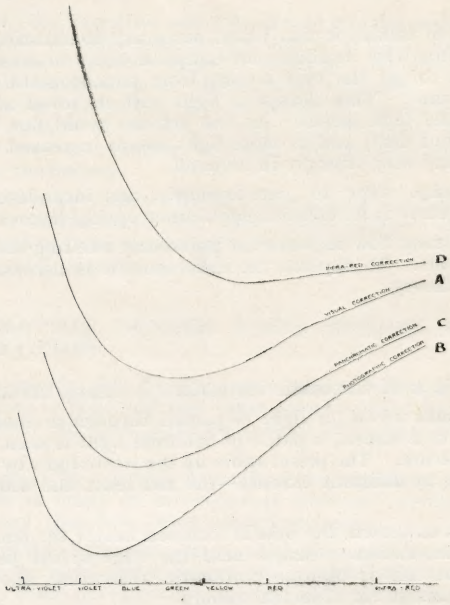
This being so, the only thing left for the designers of photographic lenses is to find some compromise solution where the bad effects of this secondary spectrum are brought within reasonable limits. Now, let us see what the results of this secondary spectrum are. They can be described by saying that as the colour of light progresses down the spectrum from red through green, towards the blue and the ultra-violet, the focus becomes shorter as you go from red towards the green, then in the blue focus begins to lengthen, in the ultra-violet it lengthens rapidly. Somewhere near the green the focus reaches a minimum.

SKETCH ON BOARD

Imagine that the problem of colour correction is this, that you have a curve this shape and it can be turned about, so that its horns (and minimum focus) comes to different positions ; but the curve cannot be straightened out by the use of any glass the chemists so far have been able to make. The same problem presents itself when designing optics for various purposes. For instance, in astronomical telescopes which are designed for visual work only as the eye is most sensitive to the yellow light waves, the minimum focus is required in the yellow and the curve is turned thus : CURVE "A" on slide No. 3.

SLIDE No. 3

This slide shows curves displaced relatively to one another, so as to show them all distinctly.



Curve " A."	Corrections for astronomical telescopes ..	VISUAL.
Curve " B."	Corrections for astronomical telescopes ..	PHOTOGRAPHIC.
Curve " C."	Corrections for Panchromatic Plates ..	
Curve " D."	Corrections for Infra-Red Plates ..	
	X = .003 in. for 3 in. F/2 Cooke.	

The minimum focus is in the yellow, the red and the green being about equally long. The blue and the violet, which are of very little importance for visual work, are ignored. This is an example of compromise solution which makes the best of the existence of the secondary spectrum for a particular purpose.

The opposite treatment of this curve is found when dealing with astronomical telescopes designed solely for photography and for plates which are not red-sensitive. In this instance the curve is turned thus :

(Curve " B ") and the minimum focus brought right down into the blue. Because of its small photographic value, the red is safely ignored.

Now the lenses designed six or seven years ago, in pre-panchromatic days, in the Kine studios, had somewhat similar corrections to those shown by curve " B." With film which is virtually red-blind, as then used, the sharpest results followed by getting a close concentration over the blue-green range, and letting the red go long. It is now easy to see why in these pre-pan days lenses proved unsatisfactory when panchromatic film was used, and the change was made from arc and mercury vapour lights, which are rich in blue-green light, to incandescent which is rich in red. As panchromatic film is sensitive to both blue and red light, neither end of the spectrum (visible) could be ignored, and the remedy that had to be applied when designing lenses was to turn back the secondary spectrum curve like this : (Curve " C ") so that equality of focus was obtained for the ends of the spectrum, and then the middle inevitably focussed short. It will give you an idea of the measurements involved to know that with the Cooke 3 in. F/2 lens the depth of this curve is about .003 in. You will see that measurement and control of such magnitudes is a delicate matter.

As you will no doubt be interested in the methods of making the colour measurements, I have brought slides illustrating an optical bench specially designed at Taylor-Hobsons for this purpose.

SLIDES Nos. 4 AND 5

The test on that bench is an essential part of the routine of all Cooke Kinematograph lenses. After passing the visual test on the bench, the lens is next submitted to photographical determination of chemical focus. One of the objects used is a board inclined at 45° to the axis of the lens.

SLIDES Nos. 6 AND 7

This board carries ruled parallel lines at a fixed distance apart, and the lens is focussed on the centre one. By having the board sloping we can photograph at the same setting not only the plane focussed on, but a depth of several inches, both before and behind.

If a lens is right for chemical focus, it will show quite sharply the line focussed on, and one or two lines both in front and behind, thus forming a measure of the depth of field.

This test is made with incandescent light, then with mercury vapour light, and lastly with carbon arc light. Panchromatic film is, of course, used in each case. Focussing is done by taking the lens in its adapter and fitting to a special focussing microscope magnifying about 20 diameters, the photograph being taken with an Eyemo camera.

As we know the distance apart of the lines on the board, it is quite an easy matter to reduce to a numerical measure any errors shown by the photographs. This, of course, is essential for us. In a test with a 3 in. lens, made at 8 ft. distance, if instead of the central line focussed on the next line to it is sharp, the error in position of the focal plane is .0003 in.

From what I have told you, I think you will see that Cooke lenses are designed to give sharp results with incandescent lighting, and that in doing so the results with arc lights have not been sacrificed.

At this stage it might be well to discuss future developments in kinematography. As before mentioned, the trend of optical developments for the cinema industry has been towards providing greater transmissions of light in optical systems, and there is every likelihood of the demand continuing. This is particularly so in the case of lenses for photography, as it is desirable from many points of view to have more speed. Larger aperture lenses would enable the studios to work with less light and, consequently less heat, to the advantage of the artistes *and* the *disadvantage* of the electric supply companies.

After speaking with many camera-men, I feel more than ever the need for the development of large aperture lenses, or, alternatively, faster films.

Most photographers are agreed that for close-ups and for frontal lighting generally the tungsten filament lighting gives the most pleasing results. Since it has been necessary to expose at 24 frames per second, and due to the fact that the incandescent light has a lower actinic value, there has resulted the natural tendency to over-lighting, with flat results. This is especially so in cases where a photographer is afraid of his large aperture, and always keeps his lens stopped down slightly. I can assure you that with some photographers this doubt still exists, and they still employ more lighting than necessary by not opening full out. I would like those photographers to know that Cooke lenses are tested at full aperture, and that there is no reason why they should be afraid of opening out and getting good definition unless, of course, they are requiring extreme depth of field.

Unfortunately, questions of depth of focus often restrict the extent to which the optician can push up the aperture of an optical system. Cinema camera makers are helping now by providing an accurate means of focussing on the film in the gate, but this cannot entirely eliminate the difficulties which arise from lack of depth. These difficulties are very real from both the camera-man's and producer's points of view. They were when the F/2 lenses replaced the F/3.5's, but by realising the difficulties they were overcome.

A development in which the restriction due to lack of depth with increased light transmission is not so serious is an optical system for sound-on-film recording or reproduction. Here the optical system works at a fixed focus, simplifying the problem.

One of the latest developments which has found practical application is the introduction of super-speed panchromatic film. This together with the re-introduction of the arc lamp, has merely postponed the demand for abnormal aperture lenses—at

any rate for non-colour work. No modification of lens corrections are needed for this film, as the colour sensitivity is practically the same as that of the old panchromatic.

Colour work was well to the front a short time ago, and is still in the offing. This demands more rapid lenses and, unfortunately, this question of depth has to be considered. The necessity for larger apertures is obvious, especially with three colours. If three lenses are used for photography, one for each colour, errors of parallax are introduced from the different viewpoint of each lens. When a single lens is used, the light needs to be split up so that each filter and negative receives only a portion of the whole admitted by the system. This problem calls for developments in more sensitive negatives, sources of illumination and optics.

I would not like to say if the much discussed wide film will come along. If it does further optical problems come with it, especially if larger apertures are required at the same time. Although F/2 lenses of 2 in. focus will quite satisfactorily cover the wide film, I doubt if any designs are available with substantially larger aperture. Unfortunately, the two demands—wider angle of covering power and increased aperture—are antagonistic from the designer's point of view.

The same demand for larger apertures is revealed in television problems, particularly on the receiving and projection instruments. I do not propose to attempt to discuss this at length, as it has already been discussed in a previous paper here.

Perhaps one of the most interesting developments lately brought to the front is that of infra-red photography. The kinematographer can hardly pass this by without considering some of the enormous possibilities opened up in this field. You have no doubt all seen some of the beautiful photographs published by *The Times*—landscapes covering distances of 30 or 40 miles, and some of you may have seen the photographs taken by Kodaks in a completely darkened room.

The idea is not, of course, new, except in its commercial application. The long distance photographs are taken with a long focus lens, using a minus blue filter and infra-red sensitive plates, thus utilising only the red and infra-red light rays. Many years ago Professor Wood, of Baltimore, made photographs in this way. Capt. A. W. Stevens, of the United States Army Air Service, has more recently taken photographs in South America covering over 300 miles.

Astronomers have applied the same principles in photographing sun-spots—incidentally, it was found that existing opinions as to the absence of atmosphere on Mars must be abandoned.

Photographs of more interest to this industry are those showing moonlight effects in daylight, due to the fact that advantage can be taken of altered colour balances with the use of infra-red rays.

I believe it was Professor Wood who found that the leaves of trees reflect the infra-red light strongly, and they therefore appear as if in the moonlight when photographed. Hitherto these infra-red sensitive emulsions have been very slow, and their maximum sensitivity has been in the region of 7,600 units near to the visible spectrum. The recent developments have resulted in emulsions with maximum sensitivity well in the invisible band, *i.e.*, above 8,000 units, and with increased speeds which are bringing this type of emulsion nearer to commercial application.

Should it prove possible to bring these infra-red sensitive emulsions into general use, you can imagine the possibilities opened up, and the change in studio practice.

This infra-red photography, if it comes to the studios, will require special corrections of the lenses, just as the introduction of panchromatic film did. The old orthochromatic film was red-blind, the panchromatic was sensitive to both the blue and the red, whilst the infra-red would be blue-blind when using an infra-red filter calling for lens corrections such as I indicated in Fig. " D."

The opticians' difficulties in correcting his lens are increased by the fact that his knowledge of the optical properties of his material is derived entirely from visual measurements. However, the necessary corrections can be made by a suitable selection of materials and design, and results in a curve which can be compared with curve " A," shown on the third slide. The corrections are such as to bring the length of focus about equal from the yellow (maximum-visual) through to the infra-red, the minimum being between the two.

Like all the other developments mentioned, this infra-red sensitive emulsion brings its demand for larger lens aperatures, particularly for cinematograph work or photography from the air, where the exposures are limited. Up to the present it has not proved a commercial proposition to provide emulsions with speeds equivalent to panchromatic stock.

In the last paper we had presented to us, Mr. Vinten stressed the desirability of having standards in the industry. I am afraid it is rather difficult to standardise photography in which the artistic plays such a large part, but it would be a great help to the lens designers if we could arrive at some standard of lens requirements as regards definition.

Taylor-Hobson have been told that results are too hard, whilst at the same time others have reported the same lenses too soft. The only thing the designers can do is to define a policy to meet the general demand.

Cooke lenses are made to give the sharpest possible results under present-day conditions, in the belief that results can be softened easily enough if required.

In the attempt to obtain the soft and so-called artistic results, the photographer often introduces diffusers which not only diffuse, but destroy the corrections for which the lens designer has passed some sleepless nights. Personally, I believe that many of these artistic results can be obtained by a good camera-man by taking advantage of the depth of focus—or lack of depth—of a large aperture lens, together with skilful lighting.

If some of Mr. Vinten's suggestions were adopted—for instance, turning the picture round so that its width is parallel to the direction of film travel, lens designs would be affected again.

In the first place, the larger frame would call for greater covering power, probably necessitating change in design of the shorter focus lenses. Secondly, Mr. Vinten's suggestion of reverting to 16 pictures per second would possibly enable the photographer to use smaller aperture lenses. These instances I quote to show the need for lens designers to have the fullest possible information regarding future requirements.

I mentioned when discussing the possibilities of infra-red photography, that the colour balances were entirely altered when using only the infra-red rays.

Due to the kindness of Messrs. Ilford, Ltd., and The Times Publishing Company, I am able to have here for your inspection about 25 photographs taken by *The Times*, using Messrs. Ilford's infra-red plates and filters and a Taylor-Hobson Cooke lens. These also admirably illustrate the value of infra-red emulsions for distance photography and penetration of haze, due to the fact that the infra-red light rays are less scattered by the moisture vapour in the air than other light rays lower down the spectrum.

In conclusion, I would say that I hope this subject of lenses which is usually looked upon as a necessary evil, has not been too uninteresting, and that if, as a result, we can arrive at any standard of requirements, I shall be more than gratified.

DISCUSSION

CHAIRMAN : I think we are all agreed that we were all greatly interested in the subject about which Mr. Oram has been speaking to-night, that of the lens. We know that cinematography would not be where it is to-day if it had not been for the assistance which the lens maker has rendered, and we all know that the Cooke lens manufacturers have been large contributors to the success of lens design. It is not an easy thing to design a lens. A tremendous amount of mathematical work precedes the grinding of the various glasses and assembling them. Mr. Oram has not told us about the enormous amount of initial testing of the rough glass used for the purpose. Such high precision as he told us it was necessary to obtain, is hardly equalled in any other branch of precision work. Our usual practice is to call for questions, so now I ask for questions. These questions should be as to the explanation of any matters in the lecture which do not appear clear, or have not been properly understood, and later on, when we have disposed of all doubtful points, I shall ask for general comments on the lens subject, past and future.

MR. VOIGHT : Just to break the ice, I am going to ask if it is possible to explain what the secondary spectrum is.

MR. ORAM : The secondary spectrum is the residue of the main spectrum, which is not, and cannot be, eliminated by any known methods of lens construction with the limited material available.

You can call it a miniature spectrum left as a result of the different proportional dispersion throughout the spectrum of the different glasses used in the lens.

MR. VOIGHT : Would not " residual " be the better word ?

MR. ORAM : Yes, I think I mentioned that word in my Paper.

CHAIRMAN : Any other questions, please ?

W. VINTEN, JUNR. : I would like to put the question as to whether the use of diffusers would have any bad effect on the focus of the lens especially in close up work.

MR. ORAM : When focussing on close-ups, most photographers want general softening off towards the back. The error or the variations of focus between two different photographers will usually give sufficient softening using the lens at full aperture. There are quite a number of photographers who stop down and introduce diffusers, and they are where they were when they started, having stopped down to sharpen and diffused to destroy it again. I would not suggest putting the lens out of focus ; in the average close-up shot you get sufficient lack of depth to give the desired result of softness.

W. VINTNER, JUNR. : Is there not one point where the lens is sharp ?

MR. ORAM : Yes, there is. If the focus be sharp on the eyes and nose at full aperture, sufficient softness will be introduced into the hair. Quite a lot of photographers use the diffuser for everything. The introduction of the diffuser causes diffusion all over the plate. Diffusers may be made of glass or gauze, and probably it is less risky to use glass, but the matter of soft focus is so varied that it is difficult to lay down any laws. Opinions and tastes differ. What we lens makers desire is some standardisation in the amount of sharpness required in the definition of a lens, then we shall be able to definitely say that a lens is right or not right.

CHAIRMAN : When Mr. Oram is asking for a definition he is asking the world to standardise taste. Any other questions, please ?

MR. BALMAIN : Mr. Oram did not say anything in regard to the use of glass filters in conjunction with the lenses. How far does the use of an optical glass filter interfere with colour correction, or does it not interfere at all ?

MR. ORAM : If it is an optical flat, the interference is negligible. The only effect is to decrease the apparent distance of the object by one-third of the thickness of the glass if it be put in the front of the lens, but it will not interfere with the correction of the lenses. If it is a so-called optical fact which is not flat, it is possible to destroy several corrections of the lens. I might say that if the filter glass is behind the lens then it definitely alters the plane of focus, to the extent of an increase of one-third the thickness of the flat.

MR. LAGDEN : The definition of a lens can be mistaken in a number of cases. Generally, prolonged development will produce the effect of increased sharpness. It will accentuate the contrast and give you that apparent definition. If you develop the negative softly the hair will be soft, but if you develop it more fully it will become wiry to a certain extent, and I think in some cases it would be quite confusing.

MR. ORAM : That is a difficulty we have to contend with. I spent a long time in making tests with boards, as you saw in the slide just now, and when you are taking a photograph of that board from some distance, say 20 or 30 feet, the resolving power of the lens is sufficient to prove that the grain size to a certain extent destroys the definition. Similarly, as soon as you lose your black and white it is very hard to say whether you have good definition or not. It is the same with the projector lens, it may have quite good definition, but if inside reflections be present a weakening of the blacks will result in apparently poor definition.

MR. LAGDEN : Two gentlemen I know took a photograph with similar Cooke lenses but they both gave different results.

MR. ORAM : Yes, it may have happened that your camera-man had a lens which was " let down " in sharpness. We did this on one occasion to some lenses on instructions from Hollywood because they were too pin-sharp. We also had a complaint from another studio that some lenses supplied about the same time were not sufficiently critical in focus. Now these lenses had all been put through the same test in our works. Another camera-man complained that although he had always had beautiful results in one studio, in another, with the same type of lens, he could not get good results. It transpired that he had changed from ordinary film to panchromatic. All these happenings occurred some six or eight years ago. We have since sent out all lenses with corrections for sharp definition, and do not depart from that practice. Lenses always get the first blame in studios when at times the fault lies in the machinery. If a lens is returned to us as faulty we test thoroughly and can take a phorograph on a plate or film with the lens supported in an adapter independent of cine apparatus. This at once proves if the lens is at fault. Many apparent optical discrepancies resolved themselves into defects caused by the machinery in which they are employed. Tripod unsteadiness, want of registration in the camera and vibration can produce effects which can easily be mistaken for optical faults.

MR. BUCKSTONE : I should like to ask how long a lens will remain efficient in ordinary use. Will the balsam deteriorate before the surfaces ?

MR. ORAM : Well, that is rather difficult to answer because it depends upon the climatic conditions. If a lens is kept in a laboratory it *may* go wrong in two or three days. We once sent a lens out to Hollywood which was sent back, and it looked like a bit of gas tube. You will get very little trouble with balsam. It is probably not generally known that alkaline water will destroy the polish of a lens more than anything. It would be rather difficult to define a period. If you were to put a lens in this room, which is now warm, it would cool down with the room. That causes condensation, and if that is allowed to remain it will ruin the lens unless it is polished again, but if the lens is kept in ideal conditions it may function ten years or more, without repairs.

MR. EVELEIGH : I should like to repeat a story I have heard that by placing a certain oil between the combinations of an F/2 Cooke lens it is possible to make it an effective F/1.5 aperture.

MR. ORAM : I have not heard of that, but it is obviously incorrect. Filling up the air space with water or oil cannot increase its aperture, which is defined by its construction. It certainly might destroy the lens.

MR. EVELEIGH : I am very glad you have made that statement, because I made the same statement, and I rather pity him.

MR. A. S. NEWMAN : But it alters the focus considerably and that would reduce its aperture. In the case of an air space which has the appearance of a convex lens it would increase the aperture. In any such case the corrections of the lens would be destroyed.

MR. HIBBERT : If I may interrupt, a patent was taken out by Dr. Grün in regard to oil, and I have a 6-in. lens which anybody may see if they wish, but the definition of F/2 is very, very soft.

MR. ORAM : We do know of such patents. We saw one filled with paraffin, but Mr. Eveleigh mentioned an F/2 Cooke lens ; it would not alter the aperture, it would not improve the definition.

CHAIRMAN : Does anybody want to make any comments on the future development of lenses, emulsions and so on ? It is a subject on which Mr. Oram has thrown out some ideas. There are some very great things developing in the studios every day and probably in the studios in future we shall see a larger amount of colour work used. Could we have some general comments, therefore, on the future lenses as used in the future studios ?

MR. EVELEIGH : Mr. Oram spoke about infra-red photography, and where that is going to lead us is interesting because when speaking about the future you have to go back to the past. As far back as 1925, in Rochester, I was shown about two thousand feet of actual infra-red cinematography : just over seven years ago. I do not know with what lens it was done, but I do know it was Kodak stock, and I know they had been working on it for 2½ years. A further point Mr. Oram raised was the one point that appealed, and that was that you could get night photography in broad sunlight. They showed me pictures which definitely gave me the idea they had been taken at night. You could not quite see where the fake was. At that time it utterly mystified me until they mentioned infra-red. In this industry, which almost jumps by decades, it seems a long time—seven years—for us to get our first night cinematography on the screen by that method, and I do not think it is any better to-day than it was seven years ago.

CHAIRMAN : Anybody else ?

MR. W. VINTEN : I would like to pay tribute to Mr. William Taylor, of Taylor, Taylor & Hobson, for his standardisation of lens mounts and particularly the lens threads and flanges.

CHAIRMAN : Any camera specialists here ? Are there any well-known operators here ? Cannot they say something about this very interesting subject ? Mr. Oram specially asked if anybody had got any colour correction difficulties in connection with his own lenses. Is there any cameraman finding such difficulties ?

MR. LAGDEN : One little point in regard to the Cooke lens. Some time ago on the market were placed a considerable number of Cooke F/3.1 at about 10s. 6d. each. I wondered the reason of that.

MR. ORAM : They were made for a special concern, and were perfectly good lenses. They were thrown on the market when that firm ceased business.

CHAIRMAN : Will the studio managers please note that no complaints are made by the cameramen. They have nothing to report, and it is up to you to produce the results.

MR. HARTLEY DAVIES : It is a great pleasure to me to propose a hearty vote of thanks to Mr. Oram. Many of the things I was going to say have been taken out of my mouth by the Chairman. I think the lecture we have had is of the utmost importance to the projection side, and I would certainly have liked to have heard more from that side, but on the whole the lecture has been most informative and illuminating and I do propose a hearty vote of thanks.

MR. VOIGHT : I came here as rather an ignoramus on the question of optics, but now I understand a little. I think we must all join in thanking Mr. Oram for the lecture he has given us to-night.

MR. ORAM : Thank you very much, and I only hope I have been able to make it clear. I have not had a great deal of experience in lecturing to a group of scientists such as are here, but if there are any other questions you would like to ask me I will do my best to answer them afterwards.

MONDAY, APRIL 3RD, 1933.

MR. E. R. DAVIES,

of Messrs. Kodak's Research Laboratory,

WILL READ A PAPER ON

"INHERENT DIFFICULTIES IN THE MEASUREMENT OF PHOTOGRAPHIC SPEED."

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